

Original Research Article

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Evaluation of Weed Management Techniques in Drip Irrigated Aerobic Rice

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ABSTRACT

A field experiment was carried out at Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy during late *Samba*, 2019 to evaluate the weed management practices on weed dynamics, weed control efficiency, growth and yield of drip irrigated aerobic rice. The experiment was laid out in randomized block design with nine treatments and replicated thrice. Treatments consist of herbigation of pre emergence (PE) pendimethalin 1.0 kg ha⁻¹ at 3 DAS + Hand weeding (HW) on 35 DAS, herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS, herbigation of post emergence (PoE) bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS, herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + spray of PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, herbigation of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS + spray of PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, spray of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, HW on 20 DAS and 45 DAS and unweeded control. Results revealed that among the different weed management practices, hand weeding twice at 20 and 45 DAS registered significantly lower weed density (8.9 m⁻²), dry weight (2.3 g m⁻²) and higher weed control efficiency (98.8 %) than unweeded control at 60 DAS. This was on par with manual spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS. Among the herbigation treatments, herbigation of PoE bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS obtained lower weed density (21.3 m⁻²), dry weight (6.2 g m⁻²) and higher WCE (97%) at 60 DAS. This was followed by herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS. Hand weeding twice at 20 and 45 DAS recorded taller plants (122.5 cm), more tillers (501 m⁻²), productive tillers (442 m⁻²), filled grains (213 panicle⁻¹) and grain yield (4305 kg ha⁻¹) than unweeded control. However, this was comparable with spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS and herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS. Thus, spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS could be recommended as viable option to control weeds in drip irrigated aerobic rice in considering the prevailing labour situation.

Keywords

Weed management,
Aerobic rice, Drip
irrigation,
Herbigation,
Pretilachlor +
bensulfuron methyl,
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Pendimethalin,
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Introduction

Rice (*Oryza sativa* L.) is the staple food for more than 60 per cent of the world population. It's cultivation secures a livelihood for more than two billion people. In India, rice is grown in an area of 43.86 million hectare with a production of 104.80 million tonnes and an average productivity of 2.4 t ha⁻¹. In Tamil Nadu, rice is grown in an area of 1.85 million hectare with a production of 6.95 million tonnes and productivity of 3.7 t ha⁻¹ (Anonymous., 2019). Rice cultivation requires large quantity of water and production of one kg rice, around 5000 litres of water is needed. Recently, ever increasing water scarcity in agriculture due to increased allocation of available water to industry and domestic uses and variation in monsoonal pattern by climate changes threatens the sustainability of rice production in a lowland ecosystem (Silalertruksa *et al.*, 2017). These situations enforce to look for an alternative means of rice cultivation which requires less water. One of the approaches that lead to a considerable amount of water saving in rice production is drip irrigation. Drip irrigation, also known as trickle irrigation is an irrigation method that applies water slowly to the plant root zone through anemitters. Aerobic rice cultivation with drip irrigation system increase water use efficiency up to 70 per cent by applying water on root zone. Aerobic rice refers to growing of high yielding rice varieties in non-puddled and non-flooded aerobic soil, with the use of external inputs such as supplementary irrigation, fertilizers and aiming at higher yields (Shanmuganathan, 2006). Crop weed competition of aerobic rice was high compared to transplanted rice, because weeds grow simultaneously with rice crop. Weed infestation was severe problem in aerobic rice, resulted in yield reduction to the tune of 56 to 90 % (Paradkar *et al.*, 1997). To reduce the yield loss, early weed suppression is

necessary to achieve higher yields in aerobic rice. Weeds could be controlled through manual and chemical methods. Manual method is though very common but cost intensive, raising cost of labour and their non-availability in time lead to the search for alternative methods. Herbicides offer the most effective, economical and practical way of weed management (Suresh Kumar and Durairaj, 2016). Chemical weed management through application of pendimethalin 0.75 kg ha⁻¹ followed by one hand weeding on 45 DAS considered as efficiency weed management strategy in aerobic rice (Ramesh *et al.*, 2009). Many years, herbicides are applied as manual spray, which consumes time, labour and also threat to environment through drift effect. Recently, non - availability of labour and high labour wages force the farmers to find out alternate method of herbicide application with lower cost of operation. Herbigation is the method of application of herbicides through irrigation water which involves less cost and labour. Further, the herbigation could be useful in reducing the labour drudgery and health related issues. An experiment at UAS, Bengaluru, Abhishek *et al.*, (2017) revealed that application of pretilachlor + bensulfuron methyl 6.6% GR at 10 kg ha⁻¹ under drip irrigation + one hand weeding on 25 DAS + one inter-cultivation on 30 DAS was recorded higher weed control efficiency and grain yield of rice. Hence, the present field experiment has been carried out to select suitable weed management technique for drip irrigated aerobic rice.

Materials and Methods

A field experiment was carried out at Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy during late *Samba (Rabi)* 2019. Total rainfall received during cropping

season was 176 mm in 12 rainy days. Mean maximum and minimum temperature were 33.5°C and 22.5°C, respectively. Mean relative humidity was 86.6 % and 52.0 % during forenoon and afternoon respectively. Mean bright sunshine hours and evaporation per day were 6.7 hrs. and 4.4.mm day⁻¹. Mean wind velocity was 4.2 km hr⁻¹.

The soil of experimental field was alkaline in nature (pH- 9.2), sandy clay-loam in texture, moderately drained, classified as *Vetric Ustropept*. The experimental soil was low in available nitrogen (218.5 kg ha⁻¹), medium in available phosphorus (14.4 kg ha⁻¹) and high in available potassium (289.8 kg ha⁻¹). The experiment was laid out in randomized block design with nine treatments and replicated thrice. Treatment consist of herbigation of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS + Hand weeding on 35 DAS, herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS, herbigation of PoE bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS, herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + spray of PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, herbigation of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS + spray of PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, spray of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS, HW twice on 20 and 45 DAS and unweeded control. As per treatment schedule, pre emergence herbicide pendimethalin 30 % EC and pretilachlor +bensulfuron methyl 6.6 % GR was given through drip irrigation on 3 DAS. Post emergence herbicide bispyribac sodium 10 % SC was given through drip irrigation on 20 DAS. Before herbigation, drip irrigation was operated for 30 minutes followed by herbigation for 10 minutes and again drip irrigation for 30 minutes was done in order to

flush out the herbicide remained in the laterals. In manual spray treatments, commercial herbicide requirements were calculated and mixed with water at 500 litres ha⁻¹ and sprayed uniformly with knapsack sprayer fitted with deflector nozzle. Unweeded control plot was kept undisturbed during entire cropping period. The rice variety TRY 3 was sowing using drum seeder under dry soil condition. Total weed density and weed dry weight were recorded at 20 and 60 days after sowing (DAS) and were subjected to square root $x+0.5$ transformation before statistical analysis to normalize their distribution. Weed control efficiency (WCE) was worked out on the basis of weed dry matter recorded in each treatment by using formula as suggested by Mani *et al.*, (1973). The growth and yield attributes like plant height, number of tillers, number of productive tillers, number of filled grains per panicle, grain yield were recorded.

Results and Discussion

Weed flora

The weed flora consisted of *Cynodon dactylon*, *Echinochloa colona*, *Dactyloctenium aegyptium*, *Chloris barbata*, *Elusine indica* in grasses, *Cyperus rotundus* in sedges and *Eclipta alba*, *Trianthema portulacastrum*, *Phyllanthus niruri*, *Lactuca serriola* in broad leaved weeds. Similar weed species have been found in direct seeded aerobic rice by Abhishek *et al.*, (2017).

Effect on weeds

Application of pre emergence herbicides had a significant effect on weed density, weed dry weight and weed control efficiency (Table 1). Among the weed management practices in drip irrigated aerobic rice, spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹

at 35 DAS registered significantly lower weed density (10.3 m^{-2}), dry weight (2.4 g m^{-2}) and higher WCE (82.4 %) at 20 DAS. This is mainly because of pretilachlor + bensulfuron methyl herbicide spray controlled the weeds effectively through inhibition of mitosis, cell division and acetolactate synthase (Sunil *et al.*, 2010). Herbigation of PE pretilachlor + bensulfuron methyl 660 g ha^{-1} at 3 DAS + HW on 35 DAS resulted lower weed density (249.7 m^{-2}), dry weight (5.8 g m^{-2}) and higher WCE (56.4 %) at 20 DAS compared to pendimethalin herbigation treatments. Unweeded control registered higher weed density (568.6 m^{-2}) and dry weight (13.9 g m^{-2}).

Hand weeding twice on 20 and 45 DAS registered significantly lower weed density (8.9 m^{-2}), dry weight (2.3 g m^{-2}) and higher WCE (98.8 %) at 60 DAS. Manual weeding removed all type of weeds especially *Cyperus* and paddy mimicry weeds which had grown along with rice, was the reason behind less weed density and dry weight and higher weed control efficiency. These results are in accordance with Yadav *et al.*, (2018) who revealed that hand weeding twice at 20 and 45 DAS was recorded lower weed density (11.0 m^{-2}), dry weight (17.33 g m^{-2}) and higher WCE (92.4%) in aerobic rice.

Hand weeding was on par with spray of PE pretilachlor + bensulfuron methyl 660 g ha^{-1} at 3 DAS + PoE bispyribac sodium 25 g ha^{-1} at 35 DAS. Reduced weed density, dry weight and higher weed control efficiency might be due to broad spectrum control of weeds by application of pretilachlor +bensulfuron methyl 660 g ha^{-1} on 3 DAS + bispyribac sodium 25 g ha^{-1} on 35 DAS.

These results are in line with the findings of Nagarjun *et al.*, (2019) who reported that PE bensulfuron methyl + pretilachlor followed by PoE bispyribac sodium which registered

lesser weed density, dry weight and higher weed control efficiency in direct seeded rice.

Herbigation of PoE bispyribac sodium 25 g/ha at 20 DAS + HW on 45 DAS obtained lower weed density (21.3 m^{-2}), dry weight (6.2 g m^{-2}) and higher WCE (97%) at 60 DAS than other herbigation treatments. Even though, herbigation of PoE bispyribac sodium 25 g ha^{-1} at 20 DAS did not control weeds, hand weeding on 45 DAS reduced the weed population considerably. This was followed by herbigation of PE pretilachlor + bensulfuron methyl 660 g ha^{-1} at 3 DAS + HW on 35 DAS.

These results are in accordance with the findings of Abhishek *et al.*, (2017) who revealed that pre emergence herbigation of pretilachlor + bensulfuron methyl 6.6% GR at 10 kg ha^{-1} + one hand weeding + one inter-cultivation registered lower weed density, dry weight, and higher WCE in drip irrigated direct seeded rice. Unweeded control recorded higher weed density (209.1 m^{-2}), dry weight (213.6 g m^{-2}) at 60 DAS. Weed density was reduced in all the plots at 60 DAS as compared to 20 DAS mainly due to continuous rain occurred during 3rd weeks after sowing led to water stagnation in the field which killed the broadleaved weeds particularly *Trianthema portulacastrum*.

Effect on plant growth parameters

Growth parameters like plant height and tillers population of rice were significantly influenced by different weed management practices (Table 2). Hand weeding twice at 20 and 45 DAS significantly recorded taller plants (122.5 cm) and more tillers (501 m^{-2}) than control. This was on par with spray of PE pretilachlor + bensulfuron methyl 660 g ha^{-1} at 3 DAS + PoE bispyribac sodium 25 g ha^{-1} at 35 DAS.

Table.1 Effect of different weed management practices on weed density (m^{-2}), weed dry weight ($g m^{-2}$) and weed control efficiency (%) of drip irrigated aerobic rice

Treatments	Weed density (m^{-2})		Weed dry weight ($g m^{-2}$)		Weed control efficiency* (%)	
	20 DAS	60 DAS	20 DAS	60 DAS	20 DAS	60 DAS
T₁ - Herbigation of pendimethalin 1.0 kg ha⁻¹ at 3 DAS + Hand weeding on 35 DAS	21.72 (471.2)	5.59 (30.7)	3.03 (8.7)	3.71 (13.2)	37.3	93.7
T₂ -Herbigation of pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS	15.82 (249.7)	5.09 (25.4)	2.52 (5.8)	3.58 (12.3)	57.8	94.2
T₃ - Herbigation of bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS	20.13 (404.4)	4.67 (21.3)	2.83 (7.5)	2.6 (6.2)	56.4	97
T₄ -Herbigation of pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + spray of bispyribac sodium 25 g ha⁻¹ at 35 DAS	17.55 (307.5)	7.06 (49.3)	2.56 (6.0)	6.17 (37.6)	45.7	82.3
T₅- Herbigation pendimethalin 1.0 kg ha⁻¹ at 3 DAS +spray of bispyribac sodium 25 g ha⁻¹ at 35 DAS	22.69 (514.1)	8.11 (65.3)	3.34 (10.6)	7.69 (58.7)	23.4	72.5
T₆ -Spray of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS +bispyribac sodium 25 g ha⁻¹ at 35 DAS	4.38 (18.1)	6.62 (43.3)	2.2 (4.3)	3.04 (8.8)	68.8	95.8
T₇ -Spray of pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + bispyribac sodium 25 g ha⁻¹ at 35 DAS	3.3 (10.3)	3.24 (9.9)	1.71 (2.4)	1.72 (2.4)	82.4	98.8
T₈ - HW on 20 DAS and 45 DAS	23.11 (533.4)	3.08 (8.9)	3.66 (12.9)	1.68 (2.3)	7.3	98.9
T₉ - Unweeded control	23.86 (568.6)	14.48 (209.1)	3.79 (13.9)	14.63 (213.6)	-	-
SEd	0.76	0.24	0.20	0.26	-	-
CD (.05)	1.61	0.50	0.42	0.56	-	-

The data were transformed to $\sqrt{X + 0.5}$. The figures in the parenthesis are original values

*The data not statistically analysed HW - Hand Weeding DAS – Days After Sowing

Table.2 Effect of different weed management practices on growth, yield parameters and grain yield (kg ha⁻¹) of drip irrigated aerobic rice

Treatments	Plant height (cm)	Total tillers (m ⁻²)	Productive tillers (m ⁻²)	No. of filled grains	Grain yield (kg ha ⁻¹)
T₁ - Herbigation of pendimethalin 1.0 kg ha⁻¹ at 3 DAS + Hand weeding on 35 DAS	109.9	380	338	176	3017
T₂ -Herbigation of pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS	117.7	462	412	203	3998
T₃ - Herbigation of bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS	117.7	445	406	199	3852
T₄ -Herbigation of pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + spray of bispyribac sodium 25 g ha⁻¹ at 35 DAS	115.6	422	394	190	3725
T₅- Herbigation pendimethalin 1.0 kg ha⁻¹ at 3 DAS + spray of bispyribac sodium 25 g ha⁻¹ at 35 DAS	111.1	408	378	183	3602
T₆-Spray of PE pendimethalin 1.0 kg ha⁻¹ at 3 DAS + bispyribac sodium 25 g ha⁻¹ at 35 DAS	107.9	391	346	181	3225
T₇ -Spray of pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + bispyribac sodium 25 g ha⁻¹ at 35 DAS	122.2	478	424	210	4117
T₈ - HW on 20 DAS and 45 DAS	122.5	501	442	213	4305
T₉ - Unweeded control	104.5	354	308	157	2300
SEd	3.8	29	13	6.7	156
CD (.05)	8.1	61	27.5	14.2	364

HW – Hand Weeding

DAS – Days After Sowing

Herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS and herbigation of PoE bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS registered similar plant height (117.7 cm) and more tillers (462 and 445 m⁻²). It might be due to adoption of different weed management practices improved the growth parameters of aerobic rice by way of higher water, nutrients and light availability for crop plants through elimination of competition by weeds during the critical period leads to higher plant height and more tillers. Similar results were obtained by Yadav *et al.*, (2018) who reported that hand weeding twice at 20 and 45 DAS recorded taller plants and more tillers. Similarly, Jagadish *et al.*, (2015) reported that spray of PE pretilachlor + bensulfuron methyl + PoE bispyribac sodium recorded higher plant height and more tillers of drip irrigated aerobic rice. Unweeded control was recorded shorter plants and lesser tillers (104.5 cm and 354 m⁻²).

Effect on yield attributes

Different weed management practices in paddy exerted significant influence on the yield attributes of drip irrigated aerobic rice (Table 2). Hand weeding twice at 20 and 45 DAS significantly recorded higher productive tillers (442 m⁻²) and more filled grains (231 panicle⁻¹) than control. This was followed with spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS (424 m⁻² and 210 panicle⁻¹). Herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS and herbigation of PoE bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS registered more productive tillers (412 and 406 m⁻²) and filled grains (203 and 199 panicle⁻¹) respectively than control. These results are in accordance with Dadsena *et al.*, (2014) who reported that hand weeding twice registered higher productive tillers in aerobic

rice. Post emergence herbicide, bispyribac sodium 25 g ha⁻¹ effectively controlled the emerged weeds during critical stages and maintains the crop free from crop weed competition and resulted in lesser competition by weeds for nutrients, space and light ultimately resulted in increased productive tillers and filled grains. These results were in conformity with Manisankar *et al.*, (2019), who reported that PE pretilachlor + bensulfuron methyl + PoE bispyribac sodium registered more productive tillers and filled grains in rice. Unweeded control registered lesser tillers (308 m⁻²) and filled grains (157 panicle⁻¹).

Grain yield

Grain yield of drip irrigated aerobic rice was varied significantly with different weed control methods. Among the weed management practices, hand weeding twice on 20 and 45 DAS registered significantly higher grain yield (4305 kg ha⁻¹) over control. However, this was on par with spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS (4117 kg ha⁻¹) and herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + HW on 35 DAS (3998 kg ha⁻¹). Herbigation of PoE bispyribac sodium 25 g ha⁻¹ at 20 DAS + HW on 45 DAS (3852 kg ha⁻¹) and herbigation of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS + spray of PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS (3725 kg ha⁻¹) was comparable with each other. Adoption of weed management practices either pre or post emergence herbicides followed by HW on 45 DAS or combination of both pre and post emergence herbicides reduced the weed density and weed competition resulted in reduced nutrient removal by weeds and increased nutrient uptake by crop, better light transmission for photosynthesis and finally better crop growth and yield. These results

were in conformity with Nagarjun *et al.*, (2019) who reported that hand weeding twice registered more grain yield and this was on par with spray of PE pretilachlor + bensulfuron methyl + PoE bispyribac sodium. Ramesh and Rathika (2020) also reported that spray of bispyribac sodium 25 g ha⁻¹ on 20 DAS recorded higher grain yield in drip irrigated aerobic rice. Lesser grain yield (2300 kg ha⁻¹) was recorded under unweeded control. This was due to severe weed competition with crop plants for water, nutrients, light and space that reduced the plant growth and resulted in lower yield components and grain yield.

Thus, considering the labour scarcity, spray of PE pretilachlor + bensulfuron methyl 660 g ha⁻¹ at 3 DAS followed by PoE bispyribac sodium 25 g ha⁻¹ at 35 DAS found effective in controlling weeds as well as higher grain yield of drip irrigated aerobic rice.

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